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THE EFFECT OF THE WESTERN UNION WEATHER DATA SYSTEM ON THE PREFLIGHT BRIEFING POSITION AT THE CHICAGO FLIGHT SERVICE STATION

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JULY 1980

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16. Abstract

An experiment utilizing a "before/after" research design was conducted to determine the effect of the Western Union Weather Data System (WDS) on the preflight briefing position at the Chicago, Illinois, Flight Service Station (FSS). Specialist activity was recorded by making written annotations on a moving paper chart called a kymograph. The average length of time spent in each activity prior to the installation of automated equipment was compared to the time spent in the same activity after automation. In addition, a questionnaire survey and personal interviews with specialists were conducted in the "after" period. The data obtained from the specialist opinion survey indicate that the WDS improved the quality of flight information service to the user pilot and improved job satisfaction for the specialist. The objective data was congruent with and in the same direction as the data that was obtained from the specialist opinion survey. However, the specialists perceived a greater reduction in workload than was measured in the before and after comparison of preflight briefing times.

17. Key Words Weather Data System (WDS) Flight Service Station (FSS) Automation Preflight Briefing Position	18. Distribution Statement Document is available to the U.S. public through the Nation Technical Information Service, Springfield, Virginia 22161

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

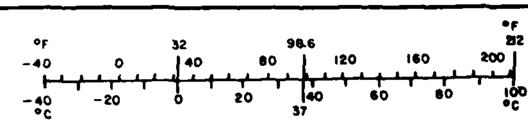

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

PURPOSE.

The purpose of this report is to document the results obtained from a study of the Chicago Flight Service Station (FSS) conducted during the periods August 11 to 15, 1975, and April 26 to May 1, 1978. This study was intended to determine the effect of the leased service, Western Union Weather Data System (WDS) on work activities of the preflight position.

BACKGROUND.

Prior to the installation of the WDS, specialists at the Chicago FSS manually manipulated teletypewriter paper which was cut, sorted, and inserted into clipboards. When requests for information were received, the specialist was required to thumb through the myriad of paper to find the data needed. The WDS, which became operational on February 19, 1978, provided the FSS with an automated means of storing, displaying, editing, sending, and receiving meteorological and aeronautical data. The noisy teletype machines and voluminous amounts of paper were replaced by a quiet, quick-responding data terminal. On request by the specialist, weather information (transmitted from the Weather Message Switching Center (WMSC) at Kansas City, Missouri, and stored in the WDS microprocessor) is presented on a cathode-ray tube (CRT) at the operating positions.

METHODOLOGY

A "before/after" research design was used to determine the effect produced by the installation of the WDS on FSS specialist work activities. Specialist activity was recorded by making written annotations on a moving paper chart called a kymograph. By this means, specialist activity was recorded exactly as it occurred during the observation period by a trained and experienced observer.

In addition to the objective data, a questionnaire was administered to 35 specialists. The questionnaire was designed to evoke a comparison between the newly installed, automated WDS and the manual system.

BEFORE AUTOMATION.

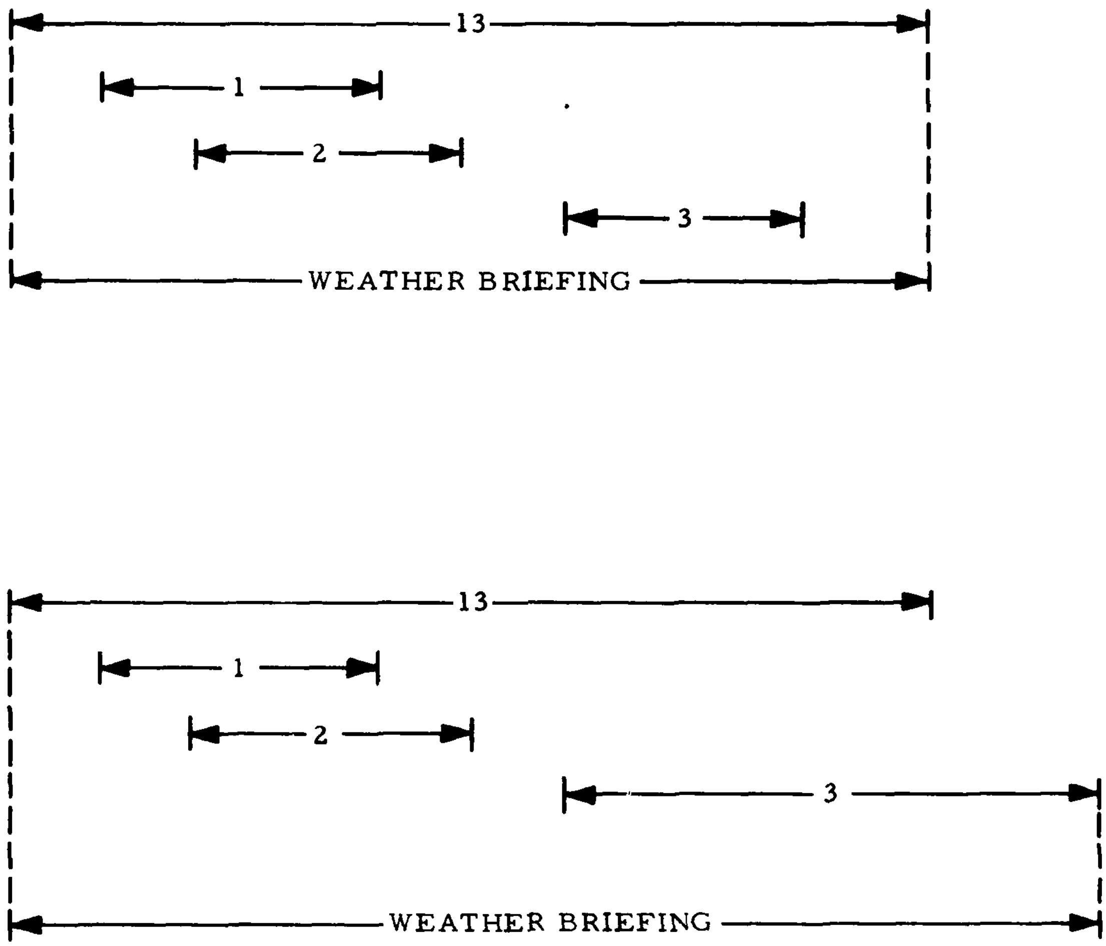
Prior to the installation of automated equipment, 13 work activities were recognized for the preflight position. These are listed in table 1. The start and end times of all activities were recorded as they occurred during the observation period. Activity 13 refers to a period during which the specialist at the prefight position and a pilot were involved in a conversation dealing with the weather and related briefing information. Many situations were observed in which at least one of the activities 1 to 12 commenced during an occurrence of activity 13 and ended sometime after the actual conversation was concluded. As a result, we were reluctant to use the duration of activity 13 as the total time devoted to the briefing of a pilot. Thus, we defined a weather briefing (WB) to consist of an occurrence of activity 13 together with any occurrences of activities 1 to 12 that commenced within the activity 13 duration. Obviously, a WB can have either of the structures depicted in figure 1, and so the duration of a WB is never less than the duration of its component activities.

AFTER AUTOMATION.

Subsequent to the installation of automated equipment, five additional work activities were observed for the preflight position. These additional activities are listed in table 2.

TABLE 1. WORK ACTIVITIES

Activity Numbers	
1	Handling teletype printouts.
2	Looking at charts, maps, manuals, etc.
3	Recording incoming contacts.
4	Manual request for printouts or maps.
5	Interphone handling of flight plan (FP) information.
6	Interphone coordination with other positions.
7	Manual coordination with other positions.
8	Coordination with another facility.
9	Movement of FSS specialist.
10	Keyboard request via teletype.
11	Briefing during position change.
12	Miscellaneous telephone communication.
13	Pilot briefing via telephone.



LEGEND:

1 HANDLING TELETYPE PRINTOUTS
2 LOOKING AT CHARTS, MAPS, MANUALS, ETC.
3 RECORDING INCOMING CONTACTS
13 PILOT BRIEFING VIA TELEPHONE

79-55-1

FIGURE 1. TYPICAL WEATHER BRIEFING STRUCTURES BEFORE INSTALLATION OF THE WEATHER DATA SYSTEM

TABLE 2. ADDITIONAL WORK ACTIVITIES AFTER AUTOMATION

Activity Numbers	
14	Use of closed circuit television (CCTV).
15	Keyboard request via Model 40 printer.
16	Flight plan information.
17	Viewing cathode-ray tube (CRT) tabular display.
18	Viewing teletype printout.

As in the "before" study, a weather briefing was defined to consist of an occurrence of activity 13 together with any occurrences of other activities that commenced within the activity 13 duration. Thus, after the installation of automated equipment, a weather briefing could have either of the structures depicted in figure 2.

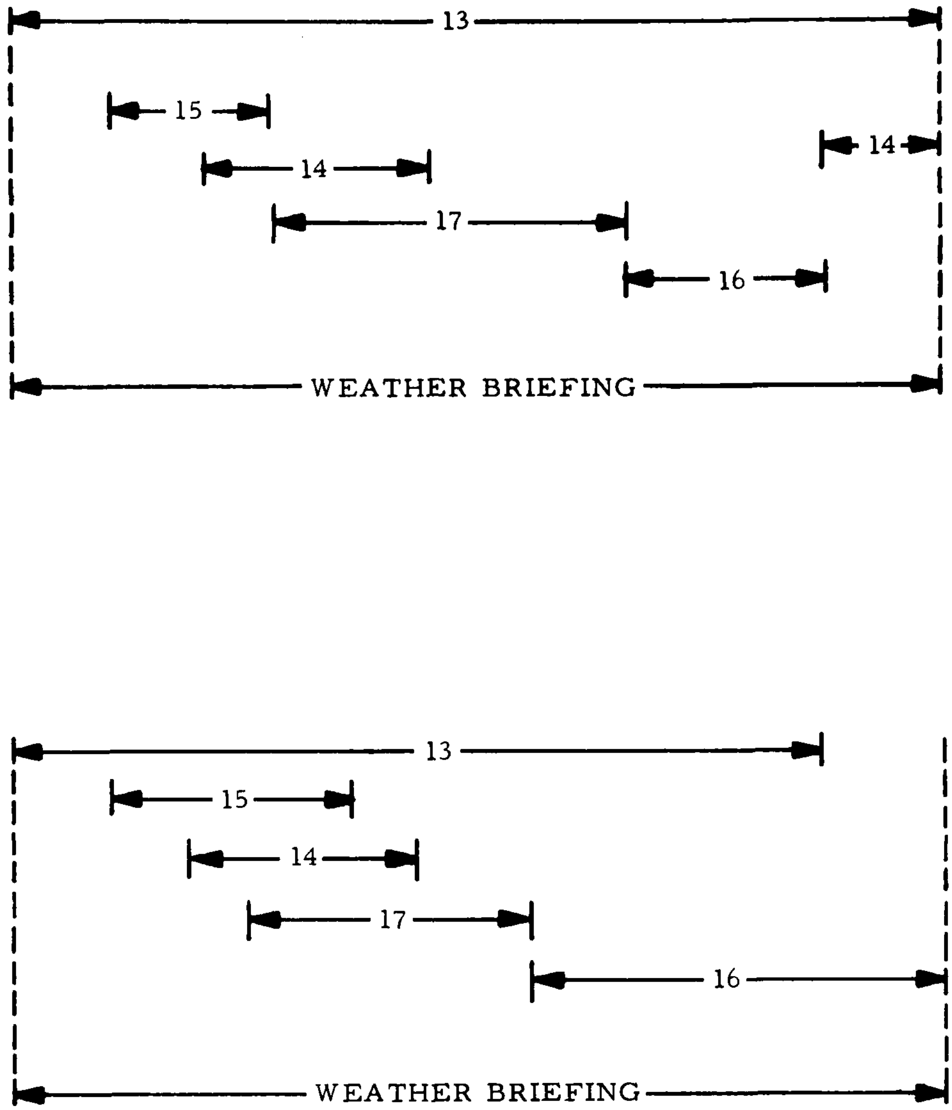
In sampling work activities by direct observation as accomplished in both the "before" and "after" periods, there was a risk that observation may have affected specialist behavior. In general, people do not behave naturally when they know they are being observed. To help compensate for this limitation, a questionnaire survey and personal interviews with specialists were conducted in the "after" study. It was felt that specialist opinion on the impact of automation would provide a valuable source of information.

The specialist opinion survey was designed to evoke a comparison between the newly installed automated system (WDS) and the manual system. Specifically, the items asked for a judgment as to whether a particular aspect decreased, remained the same, or increased following the change from manual to automated operation. A final aspect of the data collection included information obtained from 12 specialists who were interviewed regarding the impact of WDS.

RESULTS

PREFLIGHT POSITION.

Referring to table 3, 463 weather briefings were observed during the "before" period and 186 during the "after" period. In the "before" period, the sum of durations of these weather briefings was 70,148 seconds, yielding a mean weather-briefing duration of 150.7 seconds. In the "after" period, the sum of durations totaled 24,887 seconds, yielding a mean weather-briefing duration of 133.40 seconds. Prior to the introduction of automation, the total number of activity occurrences over activity types 1 to 13 was 2,611. The average number of distinct activities observed within a weather briefing was 3.4. After automation, the sum of activity frequencies was 1,064. The average number of distinct activities occurring within a weather briefing was 4.85. Table 3 can be readily understood by using activity 7 (Manual coordination with other positions) as an example. Activity 7, prior to automation, occurred at least once in 3.67 percent of the observed weather briefings. The ratio of the sum of durations of activity 7 over all weather briefings to the sum (70,148 seconds) of all weather-briefing durations was 0.00227. The relative frequency of occurrence of activity 7 over all weather briefings; i.e.,



LEGEND:

13 PILOT BRIEFING VIA TELEPHONE
14 USE OF CCTV
15 KEYBOARD REQUEST VIA MODEL 40 PRINTER
16 FLIGHT PLAN INFORMATION
17 VIEWING CRT TABULAR DISPLAY

79-55-2

FIGURE 2. TYPICAL WEATHER BRIEFING STRUCTURES AFTER INSTALLATION OF THE WEATHER DATA SYSTEM

TABLE 3. BEFORE AND AFTER SUMMARY STATISTICS—PREFLIGHT POSITION

	(1)	(2) Fraction of Total No. of WB's		(3) Fraction of Sum of WB Durations		(4) Fraction of Sum of Activity Frequencies		(5) Mean Activity Duration (sec)	
No.	Activity	Before	After	Before	After	Before	After	Before	After
1	Handling teletype printouts	0.6156	0.0269	0.09316	0.0116	0.2777	0.0075	9.0	36.0
2	Looking at charts, maps, manuals, etc	.5788	.0484	.10486	.0146	.1861	.0085	15.1	40.33
3	Recording incoming contacts	.9222	.8495	.14307	.0621	.2666	.1588	14.4	9.13
4	Manual request for printouts or maps	.0432	.0107	.00194	.0005	.0084	.0019	6.2	6.50
5	Interphone handling of FP information	.0022	.0053	.00014	.0009	.0004	.0009	10.0	22.00
6	Interphone coordination with other positions	.0022	0	.00006	0	.0004	0	4.0	0
7	Manual coordination with other positions	.0367	.0053	.00227	.0004	.0092	.0009	6.6	10.00
8	Coordination with another facility	0	.0107	0	.0012	0	.0019	0	15.00
9	Movement of FSS specialist	.1641	.0323	.01138	.0025	.0643	.0066	4.8	9.00
10	Keyboard request via teletype	.0346	0	.00624	0	.0073	0	23.1	0
11	Briefing during position change	.0022	0	.00105	0	.0004	0	74.0	0
12	Misc. telephone communication	.0863	.0053	.00235	.0030	.0019	.0009	33.0	76.00
13	Pilot briefing via telephone	1.0000	1.0000	.99443	.9976	.1743	.1748	150.7	133.40
14	Use of CCTV	-	.6021	-	.1309	-	.1222	-	25.05
15	Keyboard request via Model 40 printer	-	.6720	-	.0816	-	.1616	-	11.81
*16	Flight plan information	-	.0645	-	.0457	-	.0122	-	87.38
17	Viewing CRT tabular display	-	.7204	-	.2407	-	.1645	-	34.22
*18	Viewing teletype printout	-	.8011	-	.2315	-	.1767	-	30.63

	Before	After
No. of WB's	463	186
Sum of WB Durations (sec)	70,148	24,887
Sum of Activity Frequencies	2,611	1,064
Mean No. of Activity Types in a WB	3.4	4.85

* Although included in activity 13, activities 16 and 18 were not isolated and measured separately in the "before" study.

\- Not Applicable

the ratio of the number of occurrences of activity 7 in all weather briefings to the sum (2,611) of activity frequencies, was 0.0092. Finally, the mean duration of activity 7, taken as the ratio of the sum of durations of activity 7 over all weather briefings to the total number of occurrences of activity 7 in all weather briefings, was 6.6 seconds.

Column 5 should be read in conjunction with column 2. For example, for activity 1 (Handling teletype printouts), column 5 shows that before the installation of automated equipment, the mean activity duration was 9 seconds. After automation, the mean activity duration was 36 seconds. It would be incorrect to infer from that comparison that the installation of automated equipment resulted in an increase in the handling of teletype printouts. On the contrary, column 2 shows that prior to automation, activity 1 occurred at least one time in 61.56 percent of the briefings (285 occurrences). The mean duration of 36 seconds after automation was based on only five occurrences.

Column 2 indicates the likelihood of finding a given activity in a weather briefing. For example, prior to the installation of automated equipment, the following activities were most likely to occur in a weather briefing:

- 1 Handling teletype printouts.
- 2 Looking at charts, maps, manuals, etc.
- 3 Recording incoming contacts.
- 13 Pilot briefing via telephone.

Column 3 shows that these activities also absorbed most of the specialist's attention while he was engaged in supplying the weather information. Continuing with this example, it can be seen from column 4 that before the automated system became operational, activities 1 and 3 were repeated more often than activities 2 and 13. Morever, although column 3 shows that activity 9 (Movement of specialist) consumed a very small proportion of the specialist's time prior to the installation of automated equipment, it is clear from column 4 that this activity was repeated fairly often in comparison to many other activities.

After the installation of the automated equipment, the following activities were most likely to occur in a weather briefing:

- 3 Recording incoming contacts.
- 13 Pilot briefing via telephone.
- 14 Use of closed circuit TV.
- 15 Keyboard request via Model 40 printer.
- 17 Viewing CRT tabular display.
- 18 Viewing teletype printout.

These activities also absorbed most of the specialist's attention while he was engaged in weather briefing. After automation, activity 18 was repeated more than any other activity. The reason for this is that the specialists preferred to use teletype for selected parts of the briefing such as for "winds aloft," since information on winds aloft remains current for 12 hours of longer. Thus it was easier, more convenient, and faster for the specialists to use the teletype printout of winds aloft, as requested in most briefings, than it was to request and have this information printed by the WDS. It should also be noted that after the introduction of the WDS, the occurrence of activity 9 (Movement of specialist) was significantly reduced.

COMPARISON OF A TYPICAL BRIEFING BEFORE AND AFTER THE INSTALLATION OF THE WDS.

Before the installation of the WDS, a typical weather briefing at the preflight position consisted of the following activities within an occurrence of activity 13 (Pilot briefing via telephone):

- 1 Handling teletype printouts.
- 2 Looking at charts, maps, manuals, etc.

3 Recording incoming contacts.
9 Movement of FSS specialist.

This can be determined by examining the data in table 4. Activity 1 occurred in 62 percent of all briefings, accounting for 9 percent of the total briefing duration and having an average duration of 9 seconds. Activity 2 occurred in 58 percent of all briefings, accounting for 10 percent of total briefing duration and having an average duration of 15 seconds. Activity 3 occurred in 92 percent of all briefings, accounting for 14 percent of total briefing duration and having an average duration of 14 seconds. Activity 9 occurred in 16 percent of all briefings, accounting for 1 percent of total briefing duration and having an average duration of 5 seconds. Thus, a typical weather briefing containing activities 1, 2, 3, 9, and 13 was 150 seconds long; and of those 150 seconds, approximately 43 seconds were spent performing other activities along with activity 13 (viz. 1, 2, 3, and 9 were performed simultaneously with activity 13).

After the installation of automated equipment, a typical weather briefing at the preflight position consisted of the following activities within an occurrence of activity 13 (Pilot briefing via telephone):

3 Recording incoming contacts.
14 Use of closed circuit TV.
15 Keyboard request via Model 40 printer.
17 Viewing CRT tabular display.
18 Viewing teletype printout.

Activity 3 occurred in 85 percent of all briefings, accounting for only 6 percent of total briefing duration with an average length of 9 seconds. Activity 14 occurred in 60 percent of all briefings, accounting for 13 percent of total briefing duration and had an average length of 25 seconds. Activity 15 occurred in 67 percent of all briefings, accounting for only 8 percent of total briefing duration and having an average length of 12 seconds. Activity 17 occurred in 72 percent of all briefings, accounting for 24 percent of total briefing duration and having an average length of 34 seconds. Activity 18 occurred in 80 percent of all briefings, accounting for 23 percent of total briefing duration with an average length of 31 seconds. No remaining activity occurred in more than 10 percent of all weather briefings. As shown in table 4, a typical weather briefing containing activities 3, 13, 14, 15, 17, and 18 was 133 seconds in duration; and of those 133 seconds, approximately 111 seconds were spent performing other activities along with activity 13 (viz. 3, 14, 15, 17, and 18 were performed simultaneously with activity 13).

NUMBER OF WEATHER BRIEFINGS BY NUMBER OF ACTIVITIES.

Table 5 displays the number of WB's as a function of the number of activities occurring within a WB. Thus, three activities occurred in 138 WB's before automation and in 25 WB's after automation. From the figures shown in column 2 of table 5, it can be seen that 93.4 percent of all WB's contained two to five activity types. After automation, 89.24 percent of all WB's contained three to six activity types. The mean number of activities in a WB, as displayed in table 3, is the average of the second column of table 5 with respect to the probabilities appearing in column 3.

TABLE 4. TYPICAL BRIEFING—PREFLIGHT POSITION

No.	Activity	Weather Briefings in Which Occurred (%)	Briefing Durations Devoted to Activity (%)	Average Duration of Activity (Sec)
	BEFORE AUTOMATION			
1	Handling teletype printouts	62	9	9
2	Looking at charts, maps, manuals, etc	58	10	15
3	Recording incoming contacts	92	14	14
9	Movement of specialist	16	1	5
13	Pilot briefing via telephone	100	99	150

Percent of time devoted to other activities $= \frac{43}{150} = 29\%$ concurrently with WB

No.	Activity	Weather Briefings in Which Occurred (%)	Briefing Durations Devoted to Activity (%)	Average Duration of Activity (Sec)
	AFTER AUTOMATION			
3	Recording incoming contacts	85	6	9
13	Pilot briefing via telephone	100	99	133
14	Use of CCTV	60	13	25
15	Keyboard request via Model 40 printer	67	8	12
17	Viewing CRT tabular display	72	24	34
18	Viewing teletype printout	80	23	31

Percent of time devoted to other activities $= \frac{111}{133} = 83\%$ concurrently with WB

TABLE 5. NUMBER OF WB'S BY NUMBER OF ACTIVITIES—PREFLIGHT POSITION

(1)	(2)	(3)	(4)	(5)
	No. of WB's		Fraction of All WB's	
No. of Activities	Before	After	Before	After
1	13	0	0.028	0.0000
2	94	7	0.203	0.0376
3	138	25	0.298	0.1344
4	146	40	0.316	0.2150
5	54	48	0.117	0.2581
6	16	53	0.034	0.2849
7	2	9	0.004	0.0484
8	-	3	-	0.0161
9	-	1	-	0.0054
Total	463	186	1.0	1.0

COMPARISON OF BRIEFING DURATION.

A student's "t" test was used to compare the two sample means. The following quoted calculations and analysis were provided by the Federal Aviation Administration (FAA) Technical Center Analysis Branch, Systems Simulation and Analysis Division (reference 1):

"BEFORE

mean: $\bar{x}_b$ = 152.5 seconds

S_b = 111.4 seconds

S_b^2 = 12406.8

n_b = 445

AFTER

$\bar{x}_b$ = 133.4 seconds

S_a = 93.1 seconds

S_a^2 = 8660.5

n_a = 186

$$S^2\text{pooled} = \frac{444(12406.8) + 185(8660.5)}{185 + 444} = 11305$$

S pooled = 106.3

s.e. (standard error of estimate) =

$$106.3 \sqrt{\frac{1}{186} + \frac{1}{445}} = 9.28$$

$$\bar{x}_b - \bar{x}_a = 152.5 - 133.4 = 19.1 \text{ seconds}$$

$$\frac{19.1}{9.28} = 2.06 \text{ sig. @ approximate 4\% level}$$

"Since the type II error - the probability of accepting the initiating hypothesis when in fact it is false (β risk) has no apparent dramatic safety or efficiency impact, no evaluation of this seems indicated. It is likely though that the type II error would be larger (i.e., greater than 0.1). Because of this, all the weight of decision making must be put on the confidence of evaluating the initiating hypothesis with a type I error (α risk) i.e., stating that a real/meaningful difference exists when in fact there is not one." For this reason the alpha risk was established at the 1-percent level. Because the reduction in service time was only marginally significant in the after study, it is not clearly evident that the WDS will decrease the time required for a specialist to provide a briefing.

OPINION SURVEY.

Table 6 is a tabulation of the responses to the FSS specialist opinion survey administered to 35 specialists at the Chicago Flight Service Station. The form used is shown in figure 3. The form

TABLE 6. FSS SPECIALIST OPINION SURVEY—QUESTIONNAIRE

Aspect on which comparison is to be made	Number of respondents	A Large Decrease	A Decrease	No Change	An Increase	A Large Increase
a. Time required to give briefing	35	8	14	5	5	3
b. Job satisfaction	35	1	1	6	22	5
c. Work involved in data access	35	7	20	4	4	0
d. Utilization by private pilots	35	0	3	21	11	0
e. Overall ability to give an adequate briefing	35	0	0	6	17	12
f. Thoroughness of briefing	35	0	3	7	14	11
g. Work involved in taking flight plans	35	0	0	35	0	0
h. Speed of finding needed data	35	0	6	1	14	14
i. Likelihood of making an error	35	5	18	11	1	0
j. Amount of eyestrain	35	3	8	15	8	1
k. Ease of answering pilot queries*	34	2	4	5	19	4
l. Utilization by corporate/military pilots	35	0	1	21	11	2
m. Amount of frustration	35	7	12	10	4	2
n. Confidence in system**	34	1	4	3	17	9
o. Feeling of personal competence	35	0	0	10	17	8
p. Work involved in giving briefing	35	8	17	6	3	1

* One person failed to answer question k

** One person failed to answer question n

FSS SPECIALIST OPINION SURVEY, PART 1, GENERAL ITEMS

Now that you have had exposure to the Model-40, we would like you to answer the following questions on the basis of your experience to date. Your responses should indicate honest differences between teletype and Model-40 operations. Please give us your current opinions, not what you think we want to hear.

NAME (Optional): ______________________ DATE: ________________

LOCATION(S) OF PREVIOUS NON-AUTOMATED FSS EXPERIENCE: ______

____

1. Using your experience with both the manual and the automated systems, compare the two approaches on the basis of the following aspects. Check the most appropriate block for each aspect. Try to answer every item.

	Aspect on which comparison is to be made	Compared to manual procedures, use of Mdl-40 involves (any change?) of aspects a. to p.				
		A Large Decrease	A Decrease	No Change	An Increase	A Large Increase
a.	Time required to give briefing					
b.	Job satisfaction					
c.	Work involved in data access					
d.	Utilization by private pilots					
e.	Overall ability to give an adequate briefing					
f.	Thoroughness of briefing					
g.	Work involved in taking flight plans					
h.	Speed of finding needed data					
i.	Likelihood of making an error					
j.	Amount of eyestrain					
k.	Ease of answering pilot queries					
l.	Utilization by corporate/military pilots					
m.	Amount of frustration					
n.	Confidence in system					
o.	Feeling of personal competence					
p.	Work involved in giving briefing					

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FIGURE 3. FSS SPECIALIST OPINION SURVEY—QUESTIONNAIRE

was intended to evoke a comparison between the present automated system and the manual system. The items asked for a judgment as to whether a particular aspect decreased, remained the same, or increased following the change from manual to automated operation.

To accomplish the statistical analysis, integer numerical values were assigned to the five choices on the questionaire as follows: a large decrease—1, a decrease—2, no change—3, an increase—4, and a large increase—5.

The number of responses within each choice category was weighted by the value of that category. A mean and a standard-error-of-the-mean were computed for each aspect within each of the data sets. Student's "t" tests were performed to determine the statistical significance of the deviation of the mean response from the center of the scale (3 = no change). For those aspects where means were significantly above 3.0, the consensus of the specialists was that an increase occurred in that aspect due to the new condition. If the mean fell significantly below 3.0, a decrease in that aspect was noted. A confidence level of alpha equal to or less than 0.05 was used to determine the significance of the t score. Since there was not a prior reason to expect deviations from the mean in only single direction, two-tailed t tests were used for all items.

The questions were phrased so that the expected answers would include a balance of increase and decrease responses to encourage a careful reading of the items and to discourage stereotype answering. It is in accordance with the best current design practice to vary the dimensionality of the response category so as to guard against common sources of error, such as the halo effect (the tendency to be unduly influenced by a single or overall favorable aspect when rating separate dimensions). We want the respondents to read and respond to each item independent of the previous item or of any overall (halo) attitude toward the automated equipment.

The strong preference for the automation of selected flight service functions is strikingly evident from the statistical results presented in tables 7 and 8. Even though the questions were phrased to include a balance of increase or decrease responses, the interpreted value of the changes was positive over the entire survey. Figure 4 shows the most favorable aspects in rank order by t score. The aspect that yielded the highest t score was item e (Overall ability to give an adequate briefing).

SPECIALIST INTERVIEWS.

This section summarizes the results of the interviews with specialists conducted at the Chicago FSS regarding the impact of the WDS. The questions presented to the specialists and a summary of their responses are presented below.

PART I—QUESTIONS RELATED TO OPERATION OF THE WDS.

Question: What has been the effect of the WDS equipment in the performance of your duties at preflight, in-flight, and pilot automatic telephone weather answering service (PATWAS)?

Summary of Responses. The responses to this question fell into the following categories:

1. Weather information can be obtained faster.

2. Only the most current weather information is disseminated.

3. Teletype paper burden is relieved.

4. The system provides the specialist with the capability to retrieve information while talking to the pilot.

5. Quality of the briefing is improved.

TABLE 7. T SCORE ANALYSIS, PART I

Aspect on Which Comparison is to be Made	Mean $\bar{X}$	Standard Deviation SD	Standard Error SE	T Score	Significance
a. Time required to give briefing	2.46	1.24	.21	-2.58	*
b. Job satisfaction	3.83	0.82	.14	5.96	***
c. Work involved in data access	2.14	0.88	.15	-5.77	***
d. Utilization by private pilots	3.23	0.60	.10	2.27	**
e. Overall ability to give an adequate briefing	4.17	0.71	.12	9.81	***
f. Thoroughness of briefing	3.94	0.94	.16	5.99	***
g. Work involved in taking flight plans	3.00	0	0	0	-
h. Speed of finding needed data	4.03	1.07	.18	5.69	***
i. Likelihood of making an error	2.23	0.73	.12	-6.23	***
j. Amount of eyestrain	2.89	0.96	.16	-7.00	***
k. Ease of answering pilot queries	3.56	1.05	.18	3.15	***
l. Utilization by corporate/military pilots	3.40	0.65	.11	3.64	***
m. Amount of frustration	2.49	1.12	.19	-2.71	***
n. Confidence in system	3.85	1.05	.18	4.82	***
o. Feeling of personal competence	3.94	0.72	.12	7.70	***
p. Work involved in giving briefing	2.20	0.99	.17	-4.76	***

*Significant at .05

**Significant at .01

***Significant at .001

TABLE 8. T SCORE ANALYSIS, PART II

Aspect on Which Comparison is to be Made	Perceived Change	Perceived Value of Change	Rank	T score
a. Time required to give briefing	Decrease	+ *	14	-2.58
b. Job satisfaction	Increase	+	6	5.96
c. Work involved in data access	Decrease	+	7	-5.77
d. Utilization by private pilots	Increase	+	15	2.27
e. Overall ability to give an adequate briefing	Increase	+	1	9.81
f. Thoroughness of briefing	Increase	+	5	5.99
g. Work involved in taking flight plans	No Change		16	0
h. Speed of finding needed data	Increase	+	8	5.69
i. Likelihood of making an error	Decrease	+	4	-6.23
j. Amount of eyestrain	Decrease	+	3	-7.00
k. Ease of answering pilot queries	Increase	+	12	3.15
l. Utilization by corporate/military pilots	Increase	+	11	3.64
m. Amount of frustration	Decrease	+	13	-2.71
n. Confidence in system	Increase	+	9	4.82
o. Feeling of personal competence	Increase	+	2	7.70
p. Work involved in giving briefing	Decrease	+	10	-4.76

* + = Favorable response

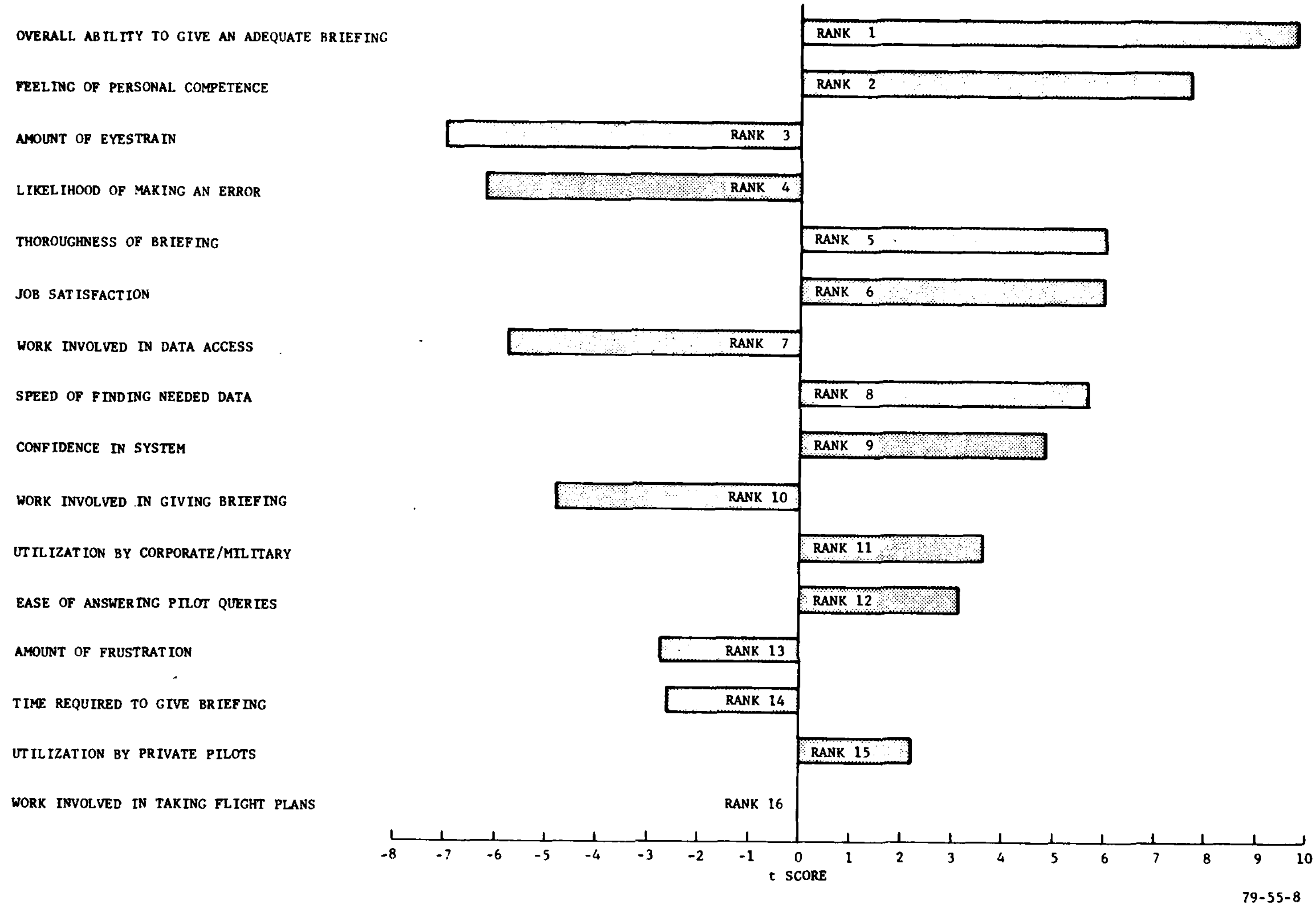

FIGURE 4. T SCORE ANALYSIS

Although numerous favorable comments were made, specialists reported serious problems with the WDS. These problems centered around (1) the frequent failure of the computer together with the accompanying loss of the data base and (2) having only one dedicated circuit to the Kansas City Weather Message Switching Center (WMSC).

The first 5 to 15 minutes of each hour was lost while the computer was being loaded with the latest weather via the Kansas City WMSC computer on the Chicago FSS's only circuit. Hence, the system was down for a 5- to 15-minute period each hour while it was receiving the latest weather information. During this period the specialists were not able to request the weather they needed for their briefing duties because that circuit, the only one available, was tied up by the WDS; This recurring problem was deemed unacceptable by the specialists who were interviewed. (Although this limitation was found on the prototype model, the system has been vastly improved with later production models.) Nevertheless, despite the limitations inherent in the prototype WDS, not one specialist interviewed preferred the manual system.

Question. Is the accuracy, speed, and thoroughness of the data balanced by the work expended to retrieve it?

Summary of Responses. The consensus of those specialists interviewed was that the speed, currency, and accessibility of information as provided by the WDS cannot be matched by a manual system. The opinions regarding the limitations of the system are as follows:

1. Inability to request more than seven items of information (one line).

2. Problems with the frequent failures of the system. A recorded comment was, "The computer is down sometimes for just 3 to 5 minutes, but the impact is for an hour since the information is lost from memory."

3. Pilot reports take too long to get into the system. "Pilot reports are so important to us, especially because we have EFAS. These reports must be transmitted to us faster."

4. Specials take too long to get into the system (anywhere from 5 to 20 minutes). Thus, the specialists may be giving the pilot information they believe to be accurate and not realize a special is in the system but not yet available. "Specials should go in sooner. Also, I would like to see a time fix added to the Hourly Observations (SA's)."

Question. What, if any, capability did you have in pre-WDS days, that you don't have today?

Summary of Responses. The consensus was that with hardcopy it was easier to self-brief and be more aware of the weather from hour-to-hour. "You get a good picture of the weather with hardcopy." One important additional advantage of the old system—where the specialist could retain 2 or 3 hours of weather information—was in getting trend information. Specialists also noted that when using the WDS it was somewhat more difficult to prebrief before taking the position.

Question. Do you occasionally use hardcopy printouts rather than the WDS, and if so, why?

Summary of Responses. Although one individual stated he never used hardcopy except when the system was down, the consensus of those interviewed favored the use of selected hardcopy for use in pilot briefings. Hardcopy was preferred at the briefing positions for long-life items such as winds aloft and Notices to Airmen (NOTAM), and on things that briefers use often, such as local area weather. It was felt that this saves time in not repeatedly calling up the same information on the WDS. Another major reason expressed for keeping

hardcopy available is for backup when the system fails, which the specialists reported occurred frequently. Finally, the use of hardcopy permitted the development of trend information. The WDS does not permit this since "old" weather is dumped from the system as soon as the updated weather becomes available.

Question. Is the response time sufficiently quick in retrieving locally stored data...remotely requested data?

Summary of Responses. The consensus was that for locally stored data that is available, the WDS is definitely faster and is preferred. However, on remotely requested data, problems do exist. Even a 15-, 20-, or 30-second delay on a remotely requested item to Kansas City (WMSC) necessitates some "dead" time requiring the specialists to work around this; e.g., using hardcopy to read winds aloft, local terminal forecasts, NOTAM, or advisories. A consensus of specialists interviewed indicated that a serious problem existed at the beginning of each hour during the time the computer was using the only line to Kansas City to obtain the updated weather. During this period of time, specialists were not able to use the WDS and consequently had to remotely request information. The specialists reported that they had to wait 5, 10, or up to 15 minutes (until the computer was loaded with the updated weather) before their request could be served. Hence, the specialists interviewed strongly recommended that Chicago FSS obtain a second dedicated line to Kansas City WMSC.

Question. Given your current knowledge of the WDS, how would you compare it with the manual system?

Summary of Responses. All of the specialists interviewed spoke favorably of the WDS when asked to compare it with the manual system. The following comments are a representative sample of the answers received to this question:

1. "It's much better. I'm a believer in it. With the WDS there is less clutter. With the manual system, you do a lot of thumbing (of paper) and this results in delays."

2. "The WDS is great compared to the old (manual) system. With the WDS, you know you have the current and the latest weather. With the manual system, sometimes the weather was 2 or 3 hours old. Once you use the WDS it's hard to do without it."

3. "It's a step in the right direction, but there are some bugs in it. Now (using the WDS) the mess is gone."

4. "I find the WDS more frustrating during the first 15 minutes of each hour while the processor is being loaded. During other situations I find it (the WDS) just slower, but I still wouldn't want to do without it. I think that we (the facility) expect too much from the Weather Data System."

Question. Does the performance of the WDS hold up during complex weather situations?

Summary of Responses. The consensus was that the specialists preferred the WDS during complex and deteriorating weather situations because of its speed and capacity for supplying immediate weather updates. The specialists stated that the problem with the WDS is that it fails too often. When this happens the backup (manual) system becomes jammed and cannot keep up with pilot demand for service. (This can be expected with a prototype system. In addition, at the time of the "after" study, there was no backup power supply for the system.)

Question. Do you believe the WDS has affected the quality of your briefing?

Summary of Responses. The consensus of the specialists was that the overall

quality of their briefing has improved. As one specialist stated, "I believe you give a better briefing using the WDS, but it depends on how you use the system. The good feature is that, using WDS, there is more information at hand." Another stated that it has improved the quality of the briefing simply because the specialist can now give the pilot information he didn't even request since additional information is readily available to the briefer.

Question. What has been the pilot's feedback on the use of the WDS in weather briefings?

Summary of Responses. Pilot reaction was mixed. Some felt they were obtaining quick response and a faster briefing, others could not detect any change. Still, a sufficient number of pilots became impatient due to the inherent limitation of the WDS as previously discussed. Quoting one briefer on pilot feedback, "To give you a general picture, I would say the negative reactions are minimal, and there have been no specific positive reactions."

PART II—QUESTIONS RELATING TO HUMAN FACTORS.

Question. Has continued use of the WDS equipment created any personal difficulties such as eyestrain?

Summary of Responses. The response to this question was "no." However, it was reported that the overhead lights in the facility created an eyestrain problem in using the CRT displays. Hence, changes to facility lighting were recommended to reduce or eliminate the glare problems created through reflections off the CRT displays.

Question. How would you rate your overall job satisfaction considering pre- and post-WDS operations?

Summary of Responses. Responses ranged from no difference to definitely improved. Most specialists reported improved job satisfaction. A representative sample of the comments received are as follows:

1. "I've always taken pride in my briefings, and with this additional source (WDS) my satisfaction has improved. Pilots verbally express appreciation when you give them a good briefing."

2. "I'm now able to do a better job."

3. "I now have more confidence in my job, and the pilots have a little more confidence in us."

PART III—QUESTIONS RELATED TO OTHER ASPECTS OF AUTOMATION.

Question. What is your personal reaction to being mandated into using the WDS?

Summary of Responses. The following comments are a representative sample of the answers received:

1. "I felt good about having some impact as to what would go into the system."

2. "The less paper I can get by with the better I like it."

3. "I feel it's a change for the better."

Question. Is the work environment in the FSS now enhanced using the WDS (i.e., does less teletype paper distribution result in reduced confusion)?

Summary of Responses. The following comments are a representative sample of the answers received:

1. "The noise environment in the facility improved."

2. "There is less confusion, less running around with teletype copy."

3. "There is a greater overall professional appearance of the facility."

Question. Is there anything you want to add or comment on?

Summary of Responses. This final question left room for a broad range of comments. Most comments related to improvements that can be made to the WDS. The following comments are a representative sample of the responses:

1. "The WDS is a step in the right direction."

2. "We definitely need a second line to the master computer (in Kansas City)."

3. "The closed circuit TV (CCTV) is a problem. You can't read the maps. There is no way to focus. The display needs to be made shorter and bigger." (Although considered a problem, the CCTV's are not part of the WDS system.)

4. "Right now you can only call up seven items (seven requests). We heard in training it could go to 11 items (requests). I would definitely prefer this, because this way you don't have to be going back and forth. It's all there on one sheet."

CONCLUSIONS

From the results, it is concluded that:

1. The installation of automated equipment:

a. improved the quality of flight information service to the user pilot;

b. reduced the likelihood of making an error or disseminating outdated weather reports; and

c. improved the specialist's feeling of personal competence and increased his job satisfaction.

2. Specialists perceived a greater reduction in workload than was measured by the before and after comparison of preflight briefing times.

REFERENCE

1. Busch, A. C., Analysis of "Before" and "After" Data from the FSS Study, letter from Analysis Branch to Flight Service Station Branch, dated December 21, 1979.

APPENDIX

DESCRIPTION OF EQUIPMENT

The equipment which supports the WDS consists of: 1 controller, 13 multiple B-500 keyboard display terminals, and 4 multiple Model 40 data terminals/printers.

The dedicated circuit to Kansas City, Missouri, operates at a speed rate of 2,400 baud. The keyboard display terminals and the Model 40 data terminals/printers also operate at 2,400 baud, or 2,400 words per minute.

CONTROLLERS.

The WDS controller is comprised of two Zilog Z-80 microprocessors, which contain a total memory of 76,000 bytes, two disk storage units, a realtime clock, and input/output port boards. Each input/output port board accommodates the required number of interfaces for the keyboard display terminals and the monitorial and supervisory printers. A separate port is dedicated to the Weather Message Switching Center (WMSC) at Kansas City, Missouri. A line patch-panel is also provided for flexibility in port assignments. The controller and the disks are mounted in the cabinet which houses the communications line patch-panel.

B-500 TERMINAL.

The B-500 keyboard display terminal consists of two pages of memory. Each page can accommodate 25 lines consisting of 80 characters each. The total capacity of the two pages of memory is 4,000 characters.

MODEL 40 DATA TERMINAL/PRINTER.

The Model 40 data terminal/receive-only printer (ROP) has a 1,000-character buffer. Each ROP is equipped with a motor control unit, the function of which is to activate the motor when the ROP is selected to receive and deactivate the motor approximately 5 minutes after a reception has been completed.

POLLING OF CONTROLLER BY THE WMSC COMPUTER.

When the computer at Kansas City polls (invites the WDS to send), or selects the controller for the reception of data, the controller automatically advises the computer whether or not it has traffic to transmit, or whether or not it is ready to receive.

The control codes used for both polling and selection are strictly between the controller and Kansas City.

TRANSMISSION TO THE CONTROLLER BY THE B-500s.

There is no polling sequence used between the WDS controller and the B-500s. When an operator has prepared and edited a request in the OFF-LINE (Local) mode, the ENTER key is then depressed for transmission of the data. The controller is constantly scanning the line to the B-500s to ascertain if a terminal wishes to send. Whenever an operator depresses the ENTER key, this action alerts the controller that a "request to send" has been initiated, and the request will be honored.

RECEPTION OF DATA.

Whether or not a request is directly or indirectly (forwarded automatically by the controller) addressed to the WMSC computer, or whether it is for data stored locally on the disks, ALL requested reports are sent by the controller directly to the inquiring B-500 operator. There is NO direct reception from Kansas City to a B-500.